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## A REPORT OF A CHEMICAL AND BACTERIOLOGICAL STUDY OF WRAPPED BREAD.

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### INTRODUCTION.

The question of wrapped bread is receiving wide attention. Sanitarians are discussing the desirability of having a law passed which will compel bakers to wrap their bread before such product can be offered for sale. This agitation has been taken up most eagerly by club women and others interested in clean foods. The bakers have discussed this subject at their meetings, the views expressed varying from extreme pro partisan to those absolutely opposed to the public's meddling with the bakers' business. Conferences with bakers have been held at which it has repeatedly been shown that the cost of wrapping bread need not be much over 5 per cent. (sometimes less), whether the bread be wrapped by hand or by machine. Experimental work done by Barnard and Bishop,\* and by Ott,† has shown that wrapped bread loses no more than 7.6 per cent. of water in 7 days, while unwrapped bread may lose as much as 17.3 per cent. and that wrapped bread was in good condition at the end of 72 to 96 hours, while at the end of three days the unwrapped bread was hard, dry, and unsalable. The National Association of Master Bakers has found this subject of such importance as to spend several thousand dollars in having a public analyst carry on research work on this subject and to make a report thereon. In this report there is nothing to show that in 48 to 72 hours wrapped bread had lost any of its flavor, texture, freshness, palatability, or other factors which go to make up quality of bread. The fact that bakers continually have so many "stales" returned should incite an investigation which might help to prevent this economic waste.

\*Indiana State Board of Health Report, 1910.

†Kansas State Board of Health, Sixth Biennial Report, 1912.

If wrapping of bread can satisfy the public in its desire for clean food, and if the cost to the baker and the public be not prohibitive, and further if it can help to do away with the return of "stale bread" and will at the same time maintain the loaf in a good condition as regards flavor, texture, palatability, freshness, etc., it is a most desirable result to achieve.

While these questions have already been studied, the Bureau of Chemistry has decided to make an investigation of wrapped bread which would take up other phases of the subject.

The experiments thus undertaken and reported herein were begun for the purpose of determining: First, the kind of paper best adapted for wrapping bread; second, the lapse of time necessary after the bread was baked before wrapping; third, bacteriological data regarding wrapped and unwrapped bread; and fourth, the relative weights of wrapped and unwrapped bread. Two bakeries coöperated with the Bureau in this work. These will be designated as Bakery No. 1, and Bakery No. 2. Nine kinds of paper presenting the greatest difference in quality, as determined by thickness, waxing, or porosity, were selected from a large variety of samples submitted. Mr. Veitch, chief of the Leather and Paper Laboratory of this Bureau assisted in this selection.

Bread wrapped and unwrapped was also purchased in a number of retail stores for bacteriological examination.

#### METHOD OF PROCEDURE IN BAKERIES.

Approximately twenty loaves of bread were placed in a steel rack immediately after being removed from the oven. Into three of these loaves thermometers were inserted. Readings on these thermometers were taken immediately and at intervals of 1, 2, 3, 4, and 5 hours after removal from the oven. The temperature of the room was noted at the same time. After the bread had been out of the oven for one hour, three loaves were weighed, wrapped and set aside. This was repeated at intervals of one hour for five hours. Three loaves were also weighed on removal from the oven and in periods of 1, 3, and 5 hours in the bakery and allowed to remain unwrapped. When the loaves were removed from the oven, one loaf was wrapped in sterilized parchment paper while hot and carried to the laboratory for bacteriological examination. All the wrapped bread remained in the bakery exposed over night and was delivered to the laboratory the next morning by one of the regular delivery wagons from the bakery. With this bread three loaves of wrapped and three loaves of unwrapped, stale bread of the day before were also delivered.

#### METHOD OF PROCEDURE IN LABORATORY.

*Bread from Bakery No. 1:* On arrival in the laboratory one loaf from each wrapping after 1, 2, 3, 4, and 5 hours, respectively, after removal from the oven, was unwrapped and weighed. A bacteriological sample

was taken of those loaves which were 1 and 5 hours old when wrapped. Weights and bacteriological samples were also taken on the fresh unwrapped and on the stale wrapped and unwrapped bread which had been delivered. At this point the bread was 18 hours old. When the bread was twenty-four hours old another set of five samples was weighed and examined and when 42 hours old the last set of loaves was weighed and examined.

*Bread from Bakery No. 2:* When this bread arrived in the laboratory it was divided into two groups, one being placed in a glass case of the same type as those used in grocery stores for keeping bread and the other was allowed to remain in the laboratory exposed. All this bread had been exposed over night and was 18 hours old on reaching the laboratory. It was allowed to remain until it was 42 hours old before being weighed. It was possible to work at this bakery but one day, and therefore only three kinds of paper, which were, however, very different from one another, were used.

#### DISCUSSION OF RESULTS OBTAINED FROM BAKERY NO. 1.

It will be seen from Table I that the bread wrapped in paper (1), which was waxed on both sides, showed a very small loss in moisture and that the loss did not increase very materially from 18 to 42 hours. In the case of paper (2), which was not a waxed paper, the loss in weight did not increase progressively with the time, but was greater than the loss obtained with paper (1). The bread in paper (3), waxed on one side, showed a higher loss than that in paper (1), but a much smaller loss than in paper (2). Paper (4) was also waxed on both sides and the bread enclosed therein showed a small loss; papers (5) and (6) were not waxed but were very thin and supposedly impervious. Samples (1) to (6), inclusive, were held in a glass case throughout the whole period from 18 to 42 hours. The last three samples, (7), (8), and (9), held in trays and unconfined in any way, showed a gradual increase in the loss of moisture. This increase in loss was reflected on the character of the crust of the bread. The crust from those samples which showed the lowest loss of moisture was soft and moist, while that from the samples having the highest loss of moisture was firm and dry. The firmness of the crust of all the bread so far as could be determined was directly proportionate to the loss in moisture. *The odor and flavor of all the samples were normal. No foreign flavor or disagreeable odor could be detected in any of the samples of bread throughout the whole period of 42 hours.*

From Table II it will be noted that those samples which were held in the glass case lost less moisture than those which were held exposed. It may also be noted that the loss of all the bread shown in this table is greater than that shown in Table I, the average loss here being 9.11 per cent. when the bread was 42 hours old, while, in Table I, the average for the bread of the same age is 2.16 per cent.



From Table III it will be seen that the average weight of the fresh wrapped bread from bakery No. 1 is 13.29 ounces, while that of the fresh unwrapped is 15.43 ounces. This shows a difference of 13.9 per cent. in weight or in other words the consumer pays 13.9 per cent. more for bread wrapped than for the same kind of bread unwrapped, both having been made from

TABLE II.

RESULTS OF EXPERIMENTS ON SAMPLES OF UNWRAPPED BREAD COLLECTED FROM BAKERY NO. 1 SHOWING THE PERCENTAGE LOSS IN WEIGHT AFTER COOLING FOR CERTAIN PERIODS OF TIME.

Weight in ounces while hot.	Percentage of loss in weight of bread per loaf after					
	1 hr.	3 hrs.	5 hrs.	18 hrs.	24 hrs.	42 hrs.
<i>Four loaves held in glass case for 42 hours</i>						
Maximum.....14.87	2.63	3.34	3.70	6.26	6.61	7.33
Minimum.....12.36	1.12	1.98	2.51	4.61	5.10	6.50
Average.....13.90	1.52	2.53	2.99	5.20	5.76	6.94
<i>Two loaves held in glass case over night</i>						
Loaf No. 1.....13.43	2.31	2.90	3.57	6.18	6.63	9.75
Loaf No. 2.....14.41	2.36	2.98	3.75	6.31	6.73	9.78
<i>Three loaves held exposed for 42 hours</i>						
Maximum.....14.03	1.82	2.43	2.88	6.13	8.64	11.82
Minimum.....13.19	1.57	2.14	2.60	5.79	8.41	11.62
Average.....13.68	1.66	2.29	2.75	5.97	8.53	11.72

TABLE III.

COMPARATIVE WEIGHTS OF WRAPPED AND UNWRAPPED BREAD.

	Bakery No. 1.				Bakery No. 2.	
	Fresh.		Stale.†		Fresh	
	Wrapped.*	Un-wrapped.†	Wrapped.	Un-wrapped.	Wrapped.§	Un-wrapped.†
Maximum.....	14.47 oz.	16.23 oz.	13.39 oz.	14.90 oz.	14.94 oz.	15.99 oz.
Minimum.....	11.66 oz.	14.32 oz.	12.05 oz.	13.69 oz.	13.14 oz.	14.62 oz.
Average.....	13.29 oz.	15.43 oz.	12.66 oz.	14.09 oz.	14.19 oz.	15.34 oz.
Average difference	13.90%		10.15%		7.50%	

\* 135 loaves weighed.

† 100 loaves weighed.

‡ 9 loaves weighed.

§ 45 loaves weighed.

dough having the same moisture content. The cost of wrapping, under the conditions which now prevail at bakery No. 1, was estimated to be approximately 6 per cent. The superintendent of this bakery stated that although the wrapped bread was being made smaller than the unwrapped, the consumer was asked to pay *only one-half the cost of wrapping, or 3 per cent.* It appears that the consumer instead of paying 3 per cent. for wrapping is paying on the average 13.9 per cent. for this desirable change.

This table also shows an average difference of 10.15 per cent. between the stale wrapped and unwrapped bread. This loss is lower than that found in the same kind of fresh bread and is due to the fact that the stale unwrapped loaves lost moisture more rapidly than the stale wrapped bread.

Table IV shows that the bread cooled very rapidly the first hour in both bakeries, but that it did not reach the temperature of the room in five hours. The wrapping in bakery No. 1 is commenced approximately two hours after the bread leaves the oven. The bread has not then reached the normal temperature of the room; therefore, when the bread is wrapped the moisture which comes to the surface is prevented from evaporating by the impervious wrapper. This accumulated moisture softens the crust, although the flavor and odor of the bread are not affected in any way which could be detected.

TABLE IV.

CHANGE OF TEMPERATURE IN INTERIOR OF LOAF AS OBSERVED DURING EXPOSURE FOR FIVE HOURS.

Bakery.	Temperature of room.	Length of time bread was exposed before temperature was recorded.					
		2 minutes.	1 hour.	2 hours.	3 hours.	4 hours.	5 hours.
No. 1..	23.4°C.	98.3°C.	43.4°C.	32.8°C.	28.8°C.	26.9°C.	25.9°C.
No. 2..	30.0°C.	97.9°C.	49.4°C.	34.9°C.	30.4°C.	29.8°C.	27.7°C.

#### DISCUSSION OF RESULTS OBTAINED FROM BAKERY NO. 2.

It will be seen from Table V that the bread wrapped in paper (1), which was waxed on both sides, showed an average loss when 42 hours old of 0.44 per cent.; that in paper (3), waxed on one side, showed an average loss of 0.95 per cent., and that in the parchment paper (2), which was not waxed on either side, showed an average loss of 4.42 per cent. The loss increased progressively with the age of the loaf but was always highest in those loaves wrapped in parchment paper and always lowest in those loaves wrapped in the paper having both sides waxed. Here again, as in Table I, the relative losses in the weight were noticeable on the character of the crust of the bread. The crust from the bread wrapped in paper (2) which

TABLE V.

RESULTS OF EXPERIMENTS ON SAMPLES OF WRAPPED BREAD COLLECTED FROM BAKERY NO. 2, SHOWING THE PERCENTAGE  
LOST IN WEIGHT AFTER COOLING FOR CERTAIN PERIODS OF TIME.

Kind of paper used for wrapping.	Weight of bread before wrapping.						Percentage of loss in weight of bread per loaf after.											
	Ounces.						42 hours exposed. Wrapped after				90 hours exposed. Wrapped after				18 hours exposed. 72 hours confined. Wrapped after			
	1 hr.	2 hrs.	3 hrs.	4 hrs.	5 hrs.		1 hr.	2 hrs.	3 hrs.	4 hrs.	5 hrs.	1 hr.	2 hrs.	3 hrs.	4 hrs.	5 hrs.	1 hr.	2 hrs.
(1) White FF, waxed both sides.....																		
	14.04	13.55	13.87	14.22	14.33													
	14.41	14.35	13.92	14.33	14.44													
	14.75	13.94	13.82	14.26	14.02													
				*														
(2) Unwaxed parch- ment.....	14.45	14.30	14.55	13.40	14.00		6.23	3.50	3.44	3.58	5.36							
	13.87	13.97	13.82	13.31	14.18							10.01	8.25	10.79				
	14.68	14.30	14.14	14.22	14.15													
(3) No. 31, waxed one side.....	14.29	14.71	14.03	14.50	14.00		1.12	1.02	0.78	0.55	1.29							
	14.51	14.51	14.04	13.93	14.54							4.07	3.63	3.37				
	13.14	14.44	14.61	14.65	14.94													
Maximum.....	14.75	14.71	14.61	14.65	14.94													
Minimum.....	13.14	13.55	13.82	13.31	14.00													
Average.....	14.24	14.21	14.09	14.10	14.29													

\* Lost.

showed the highest loss of weight was the firmest and driest, while that from the bread wrapped in paper (1) was soft and moist. The odor and flavor of all the samples were normal, and nothing disagreeable was to be detected in any of the samples throughout the whole period of 114 hours. That wrapped bread undergoes a greater loss in moisture when exposed than it does when confined in a glass case is also shown.

It will be seen from Table VI that the loss in weight progresses with the age of the bread.

It will be noted from Table III that the wrapped bread from bakery No. 2 has an average of 14.19 ounces, while the unwrapped bread shows an average of 15.34 ounces, or a difference in favor of the unwrapped bread of 7.5 per cent. When this difference is compared with that obtained in Table III from bakery No. 1, which was 13.9 per cent., it is seen that although bakery No. 2 is charging the consumer all it costs to wrap the bread, it is not trying to discourage wrapping by making an added profit out of it.

TABLE VI.

RESULTS OF EXPERIMENTS ON SAMPLES OF UNWRAPPED BREAD COLLECTED FROM BAKERY NO. 2 SHOWING THE PERCENTAGE LOSS IN WEIGHT AFTER COOLING FOR CERTAIN PERIODS OF TIME.

Loaf Number.	Weight in ounces while hot.			Percentage of loss in weight of bread per loaf after being exposed					
	1 hr.	3 hrs.	5 hrs.	1 hr.	3 hrs.	5 hrs.	42 hrs.	90 hrs.	42 (confined 48 hrs.).
1.....	13.74	13.49	13.33	1.82	2.98	3.42	7.79		
2.....	14.34	14.19	14.14	1.44	2.47	2.82	6.60		
3.....	14.22	13.98	13.81	1.69	2.88	3.16	7.60		8.93

#### BACTERIOLOGICAL EXAMINATION.

The bacteriological examination of the bread was made of the outside of the loaf only. A thin portion of the crust was removed with a sterile knife from the top, bottom and two sides of the loaf—those parts which are evidently most frequently touched during handling. About 8 sq. cm. of the crust were removed, placed in sterile weighing bottles, weighed and shaken with nine times its weight of sterile water and with sterile shot for twenty minutes. The liquid was then examined and results recorded according to the methods recommended by the American Public Health Association.\* One cc., 0.1 cc., and 0.01 cc.† were plated upon nutrient

\*Standard Methods for the Examination of Water and Sewage, 2nd edition by American Public Health Association, 1912, pp. 76-136.

†These dilutions were used because they are at present accepted by the American Public Health Association as the most satisfactory in determining the bacterial contents of substances. It will be understood, however, that results thus obtained are only relative and that no attempt is made at present in practical work to determine accurately the total number of individual organisms present in original samples.



agar,\* incubated for four days at 25°C. and 37°C., and upon wort agar,† incubated for four days at 25°C. Inoculations were also made into tubes of dextrose fermentation broth,\* lactose bile,\* and shake cultures in dextrose agar,‡ all of which were incubated four days at 37°C.

From the lactose bile tubes, which showed gas, isolations were made by plating upon MacConkey's bile salt agar,§ and identification made of organisms of the *B. coli* type by growth upon ordinary kinds of differential media, including Russell's double sugar agar.||

#### RESULTS OF BACTERIOLOGICAL EXAMINATION.

The results of the examination of samples of wrapped and unwrapped bread collected in bakeries Nos. 1 and 2 and from various retail markets in Washington follow:

TABLE VII.

#### RESULTS OF THE BACTERIOLOGICAL EXAMINATION OF UNWRAPPED, FRESH BREAD COLLECTED FROM BAKERIES.

	Number of organisms per gram developed after 4 days' incubation on:			
	Nutrient agar at		Wort agar at 25°C.	Dextrose shake agar at 37°C.
	25°C.	37°C.		
			Four loaves, fresh from the oven.	
Maximum . . . . .	80	70	50	30
Minimum . . . . .	10	less than 10	less than 10	less than 10
Average . . . . .	42	37	15	7
		Three loaves, cooled five hours in bakery.		
Maximum . . . . .	5,200	7,900	900	800
Minimum . . . . .	170	130	60	200
Average . . . . .	2,823	3,476	593	400

No gas-producing organisms found in bile or dextrose fermentation broth inoculated with 0.1 gram quantities.

Molds developed on wort agar from all loaves cooled in bakery.

Gas-producing organisms developed in dextrose shake agar from all loaves cooled in bakery.

\*See footnote (\*) page 728.

†John W. H. Eyre, M. D., *The Elements of Bacteriological Technique*, 2nd edition, 1913, p. 176.

‡*Ibid.*, 1913, p. 225.

§*Ibid.*, 1913, p. 205.

||Russell, F. F., *The Isolation of Typhoid Bacilli from Urine and Feces with the Description of a New Double-Sugar Tube Medium.* (Reprinted from the *Jour. of Med. Research*, Vol. 25, No. 1.)

TABLE VIII.

RESULTS OF THE BACTERIOLOGICAL EXAMINATION OF BREAD WRAPPED  
IN PAPER OF KNOWN QUALITY.

Kind of paper used for wrapping.	No. of organisms per gram developed after 4 days' incubation on:			
	Nutrient agar at		Wort agar at 25°C.	Dextrose shake agar at 37°C.
	25°C.	37°C.		
Cooled one hour in bakery before wrapping.				
(1) White F. F., waxed both sides. . . . .	400	440	360 20 molds	300
(2) Unwaxed parchment, 25 W. . . . .	70	140 10 molds	70 molds	1 mold
(3) White F. F., waxed one side. . . . .	700 300 molds	270	1,000 molds	(a)
(4) Tattoo amber, No. 5 B	500	340	1,500 molds	400
(5) Bison Glassine 20 . . . .	30	80	240	(a)
(6) Bison Grease-proof 20. .	110 1,600 molds	110	1,400	40*
(7) One side waxed, No. 31	20	30†	50	40*
(8) Both sides waxed, No. 18. . . . .	70	100	100 molds	(a)
(9) "A" Fibre. . . . .	20	90	90 molds	90*
Cooled five hours in bakery before wrapping.				
(1) White F. F., waxed both sides. . . . .	250 50 molds	330	130	100
(2) Unwaxed parchment 25 W. . . . .	240 20 molds	90	50 20 molds	50
(3) White F. F., waxed one side . . . . .	20	10	30 30 molds	(a)
(4) Tattoo amber No. 5	36,000	28,400†	12,500 400 molds	50,000*
(5) Bison Glassine 20 . . . .	30 40 molds	50 30 molds	300 500 molds	60*
(6) Bison Grease-proof 20. .	300 200 molds	170	80 40 molds	70*
(7) One side waxed, No. 31	70	50†	20 molds	40
(8) Both sides waxed, No. 18. . . . .	30	70†	40	20
(9) "A" Fibre. . . . .	480	390	70 40 molds	500

\* Gas-producing organisms found in dextrose shake agar inoculated with 0.1 gram quantities.

† Gas-producing organisms found in bile fermentation tubes and dextrose broth tubes inoculated with 0.1 gram quantities.

(a) No visible growth in 0.1 gram quantities.

It will be seen from Table VII that the crust of bread is practically sterile when it is removed from the oven, but after being allowed to remain exposed in the bakery it may collect a large number of bacteria on its crust. It may be noted, however, that no organisms of the *B. coli* type were found in 0.1 gram quantities of this bread.

It will be noted from Table VIII that the bread which was cooled one hour before wrapping has a higher number of molds than that cooled five hours. The samples showing the greatest number of molds are samples (3), (4), (6), and (8). The paper used for these samples was waxed on one or two sides. In this table sample (4) has been omitted because of its abnormally high count, suggestive of faulty manipulation in examination.

TABLE IX.

RESULTS OF THE BACTERIOLOGICAL EXAMINATION OF BREAD COLLECTED FROM RETAIL MARKETS.

	Number of organisms per gram developed after 4 days' incubation on:				Number of molds per gram developed after 6 days' incubation on wort agar at 25°C.
	Nutrient agar at		Wort agar at 25°C.	Dextrose shake agar at 37°C.	
	25°C.	37°C.			
	Twenty-nine loaves of unwrapped bread.				
Maximum.....	7,000	5,500	10,000	7,000	1,600
Minimum.....	190	70	110	40	20
Average.....	1,917	1,186	1,105	864	482*
	Twenty-eight loaves of wrapped bread.				
Maximum.....	900	190	500	300	500
Minimum.....	20	20	less than 10	less than 10	10
Average.....	136	80	81	44	82†

\* Twenty-three loaves showed growth of molds.

† Eighteen loaves showed growth of molds.

Gas-producing organisms found in bile and dextrose fermentation tubes inoculated with 0.1 gram quantities from eighteen loaves of unwrapped bread.

Gas-producing organisms found in bile and dextrose fermentation tubes inoculated with 0.1 gram quantities from two loaves of wrapped bread.

Table IX shows the result of the analysis of 29 samples of unwrapped bread and of 27 samples of wrapped bread purchased in various retail markets. It may be seen that the average counts in the various media as shown in the latter is much lower than the corresponding average counts shown in the former.

Sixty-two per cent. of the samples of unwrapped bread showed organisms of the *B. coli* type in 0.1 gram quantities, while only 7 per cent. of the wrapped bread showed the presence of these organisms.

These two tables show clearly the actual conditions in which consumers receive wrapped and unwrapped bread.

#### CONCLUSIONS.

From the experiments herein reported the following conclusions may be drawn:

First, the kind of paper used for wrapping bread controls, to a large extent, the loss in moisture sustained by the bread. Paper waxed either on one or both sides causes the bread wrapped within it to retain its moisture longer than pervious paper. It is therefore evident that in the case of breads whose crusts are to be kept comparatively firm and dry, such, for example, as Vienna and French breads, porous paper, having no wax on either side, may be best. For the ordinary type of bread none of the paper used showed detrimental results.

Second, the time necessary before bread may be wrapped may be established at approximately three hours, as this was the time at which the bread reached approximately the normal temperature of its surroundings.

Third, the relative weights of wrapped and unwrapped bread showed that in these experiments with two bakers the unwrapped bread is from 7.5 to 13.9 per cent. greater than the wrapped bread, this reduced weight of the wrapped bread having a tendency to discourage its use in the home. In view of the facts, brought out by many conferences with bakers who wrap bread, that the cost need not greatly exceed 5 per cent. (if indeed it even reaches this figure), there should be no justification on the part of the baker to reduce the weight of wrapped bread to the extent of 7.5 to 13.9 per cent.

Fourth, that unwrapped bread shows signs of becoming stale sooner than wrapped.

Fifth, so far as could be detected by organoleptic tests there was nothing objectionable developed in wrapped bread in a period of 114 hours.

Sixth, bread as it comes from the oven has a practically sterile crust.

Seventh, bread which was cooled only one hour before wrapping retained heat and moisture enough to favor the growth of certain organisms, especially when paper waxed on one or both sides was used.

Eighth, bread may become contaminated with organisms while cooling in the laboratory; therefore, it should be wrapped as soon as it is sufficiently cooled.

Ninth, the surface of wrapped bread purchased from retail markets was more nearly free from organisms than unwrapped bread obtained at the same time from the same sources, and fewer loaves of this wrapped bread showed the presence of organisms of the *B. coli* type.